

- Trend discussion to be published in Journal of Applied Physics, April 2015
- Today's Environment

	<b>NAND SSD</b>	<b>HDD</b>	<b>LTO TAPE</b>	<b>ENT TAPE</b>	<b>OPTICAL BD</b>
Component	2.5" drive	3.5" drive	LTO cartridge	Enterprise cartridge	12 disk cartridge
Volumetric Strategy	2 bits/cell	5 platters	840 m tape	840 m tape	3 layer disk
Capacity	1 TB	5 TB	2.5 TB	4 TB	1.2 TB

- Best Case Scenarios

	<b>AD Increase (2008-20013)</b>	<b>5 Year AD Increase (2019)</b>	<b>10 Year AD Increase (2014)</b>
LTO TAPE	28%/yr	3.4X	11.8X
ENT TAPE	28%/yr	3.4X	11.8X
OPTICAL BD	12%/yr (18%/yr)	2.3X	5.2X
NAND	35%/yr	4.5X	20.1X
HDD	18%/yr	2.3X	5.2X

2015 Scenario

- HDD
  - No HAMR **yet**
  - More platters
  - “Duopoly” and technology
  
- TAPE
  - LTO7 will deliver on capacity target (6 TB) in the consortium roadmap
  
- Optical BD
  - Land and Groove recording and double sided disks ?
  
- NAND
  - 2D 16 nm cells pervasive
  - Some 2D 13 nm cells
  - 3D multi-layer adopted by all NAND companies

2016, 2017, 2018 Scenario

- HDD
  - No HAMR **yet** (2017?)
  - More platters?
  - HDD companies and SSDs
  
- TAPE
  - LTO8 will deliver on capacity target (12 TB) in the consortium roadmap
  
- Optical BD
  - Land and Groove recording and double sides disks ?
  
- NAND
  - 3D multi-layer pervasive
  - By 2018 (+4 Years from today) density goes up by a factor of  $1.35^4 = 3X$  minimum
  - NAND investment for increased capacity?

## 2018 and Beyond

- HDD
  - Density plateaus at 2.0 Tbit/in<sup>2</sup> to 2.5 Tbit/in<sup>2</sup>.
  
- TAPE
  - Thin film media
  
- Optical BD
  - Difficult transition to 300 - 500 GB platters
  
- NAND -3D
  - Will 80+ layer structures be feasible assuming 4 processing cycles of 20 layers each
  - Will cost issues close
  - Will PB shipments approach HDD
  
- NAND replacing HDD (16 nm node)
  - \$3.5B NAND factory produces 2.5 EB
  - 100 EB requires 40 factories (\$125B)

